# The January 1996 Flood on the Lower Susquehanna River

## Analysis and Recommendations by the Interstate Committee on Emergencies, Jams and Meteorological Systems

*Publication No. 180* *November 1996*

Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102-2391


STATE LIBRARY
OF PENNSYLVANIA
17 45

# The January 1996 Flood on the Lower Susquehanna River

## Analysis and Recommendations by the Interstate Committee on Emergencies, Jams and Meteorological Systems

*Publication No. 180* *November 1996*

*Prepared by*

*Andrew Dehoff*
*Water Management Division*
*Susquehanna River Basin Commission*

*Presented to*
*Maryland Emergency Management Agency*
*on*
*November 26, 1996*

## CONTENTS



## APPENDIXES



## ILLUSTRATIONS

## ACKNOWLEDGMENTS

This report and the review and recommendations presented herein were developed through the efforts of the Water Management Workgroup and Interstate Committee on Emergencies, Jams and Meteorological Systems (ICEJAMS). The participants in the ICEJAMS committee are presented below.

Stan Brua, U.S. Army Corps of Engineers
Jim Brunot, SECO–Conowingo
Patrick Naugle, SECO–Conowingo
Bill Peirson, SECO–Conowingo
Don Baldwin, SECO–Conowingo
Bob James, USGS Towson, Md.
Randy Durlin, USGS Lemoyne, Pa.
Marshall Kaiser, Safe Harbor Water Power Corp.
Orin O'Donel, Safe Harbor Water Power Corp.
Roland Moor, PP&L–Holtwood Operations
Harry Spagnola, PP&L–Holtwood Operations
Gregg Rishel, NWS, State College, Pa.
J. Michael Weaver, PECO–Peach Bottom
Doug Weaver, York Haven Power Co.
Brad Iarossi, MDE, Dam Safety
Bob Summers, MDE
Kum Sung Wong, MDE
Bill Parrish, MDE
Emmett Duke, Congressman Gilchrest's office
Gerald Cross, FERC
Walt Nickelsberg, NWS, Mount Holly, N.J.
Joe Miketta, NWS, Mount Holly, N.J.
Mike Conway, Pa DEP, Dam Safety
John McSparran, SRBC
George Lazorchick, SRBC
Andrew Dehoff, SRBC

Bob Summers and the Maryland Department of the Environment were especially instrumental in creating the work group and the committee. Additionally, ICEJAMS is grateful to Holtwood, Safe Harbor, Conowingo, Muddy Run and Peach Bottom for hosting the committee meetings, and grateful to all the utilities and agencies for providing information and technical expertise.

# The January 1996 Flood on the Lower Susquehanna River

## Analysis and Recommendations by the Interstate Committee on Emergencies, Jams and Meteorological Systems

*Prepared by Andrew Dehoff, Susquehanna River Basin Commission*

## INTRODUCTION

In response to the flood of January 20, 1996, and its impact on the Town of Port Deposit, Maryland, Governor Glendening called for a comprehensive review of the flood. He requested the Maryland Emergency Management Agency (MEMA), headed by David McMillion, to coordinate an evaluation of the flood handling and to develop recommendations for improvements. Two workgroups were formed to accomplish this task. The Alert and Notification Workgroup, chaired by Ruth Mascari of MEMA, was charged with the review of procedures used for the notification of emergency personnel and the public. The second workgroup, the Water Management Workgroup, chaired by Dr. Robert Summers of the Maryland Department of the Environment (MDE), was responsible for the review of the technical aspects of flood water management. MEMA sponsored meetings on February 13, 1996, in Baltimore and on February 22 and March 27, 1996, at SECO's Conowingo Visitor Center.

One of the Water Management Workgroup's duties included the review of the communication of river observations and dam operations data between the dam operators on the lower Susquehanna River and the National Weather Service (NWS) for flood forecasting purposes. The workgroup concluded there was no evidence of improper operations; the dam operators managed the flood waters appropriately, given the river ice conditions and the unexpected severe flooding. The hydroelectric dams on the lower Susquehanna have virtually no capacity for flood storage, and thus were not expected to perform as such. The system of flood control reservoirs located upstream in Pennsylvania and New York did reduce the flood flows about 15 percent, storing enough water to prevent about $1.4 billion in damages. Had the flows not been reduced, the surge and magnitude at the Town of Port Deposit would have been substantially greater. Although the hydroelectric dams could not control the flood event itself, the workgroup felt there were certain steps that could be taken to improve local flood evacuation plans, flood forecasting, ice jam monitoring and communication and operating procedures to improve the management of future flooding along the main stem of the lower Susquehanna River.

Although communication to the Town of Port Deposit was good during the January 1996 flood, the town did not have a flood evacuation plan, nor did the officials react quickly enough to the information they received. Additionally, the Flood Forecast and Warning System did not function optimally. The State College office of the National Weather Service supplied forecasts as far south as the Pennsylvania-Maryland border; however, there was a lapse in coverage for the Maryland locales of the Town of Port Deposit, Perryville, and the area west of the river.

The Susquehanna River Basin Commission (SRBC) offered to convene a technical committee to carry out a more detailed technical review of these issues and to make appropriate recommendations. The committee included the members of the Water Management Work Group, and was expanded to include Dam Safety

representatives of Pennsylvania, Maryland and FERC, USGS, and upstream power plants. The new interstate committee was named the Interstate Committee on Emergencies, Jams and Meteorological Systems, or ICEJAMS. The committee's objective was to review the hydrology, hydraulics, flood forecasting, physical facilities, operations, monitoring and other related information to develop flood management improvements for the Susquehanna River below Harrisburg.

ICEJAMS met on the following dates and locations:

| | |
|---|---|
| April 18, 1996 | SECO-Conowingo Visitors Center |
| May 7, 1996 | PP&L's Holtwood facility |
| June 27, 1996 | Safe Harbor Water Power Corporation |
| August 29, 1996 | PECO-Peach Bottom Atomic Power Station |
| October 10, 1996 | PECO-Muddy Run Information Center |
| October 31, 1996 | PECO-Muddy Run Information Center |

## RECONSTRUCTION OF FLOOD EVENT AND ESTIMATION OF FLOW MEASUREMENTS

An unusual combination of meteorological and hydrological conditions during January 1996 set the stage for a major flood in the Susquehanna River Basin. Two major snowstorms covered most of the basin with 24 to 36 inches of snow. By the middle of January, National Weather Service data indicated there was a snowpack throughout the basin that contained the equivalent of 3.5 to 5 inches of rain. An extended period of abnormally cold temperatures precluded any of the snow from melting and also caused the formation of ice on the Susquehanna River and its major tributaries.

The weather changed dramatically on January 18 and 19. Air temperatures rose from the 30s to the 50s in less than 24 hours. Strong southerly winds of up to 50 miles per hour accompanied the rapid rise in temperatures, and the combination of these conditions caused the accumulated snowpack to begin to ripen. Ripening is the process in which a deep, fluffy, absorbent blanket of snow becomes saturated as high winds and temperatures raise the temperature of the snow to 32°F and melting begins. A storm followed shortly thereafter, delivering an average of 2.5 inches of rain to the basin in about 3 hours. Because the snowpack was already saturated, it was unable to absorb any of the rainfall. In addition, the ground was still frozen, so it was unable to absorb any of the rapid snowmelt or the intense rainfall. These meteorological conditions produced rapid excessive runoff throughout the region, resulting in basin-wide flash flooding.

With 3 to 4 inches of runoff occurring simultaneously throughout the basin, river levels rose quickly, causing the ice cover on the river to break up. As the ice chunks washed downstream, many jams formed at bridges and natural constrictions in the river. The formation of ice jams can cause flooding in two ways. First, ice jams act as dams, backing up ice and water behind the jam, which can cause flooding upstream. Then, when the ice jam eventually breaks free, the rapid release of the backwater can cause a surge that floods downstream areas.

An ice jam just downstream of Harrisburg backed up water in the Susquehanna River and caused the first type of flooding to occur in Harrisburg. Figure 1 shows the hydrographs (flow of river versus time) for the U.S. Geological Survey (USGS) stations at Sunbury, Harrisburg, and Marietta, Pennsylvania. The Sunbury hydrograph shows the smooth rise of the river unaffected by ice jams. The river at Sunbury peaked around 11:00 p.m. on January 20 at a flow of 424,000 cfs. The jagged surge and interruption of the hydrograph at Harrisburg are characteristic of the effects of the water backed up behind ice jams. It should be noted that the Harrisburg hydrograph is not truly representative of the flow in the river at Harrisburg. The shape of the hydrograph demonstrates the ice jam downstream of the gage was acting as a dam, and water was ponding behind it.

Due to the ice jam, the water level at Harrisburg rose quickly to flood stage, jumping

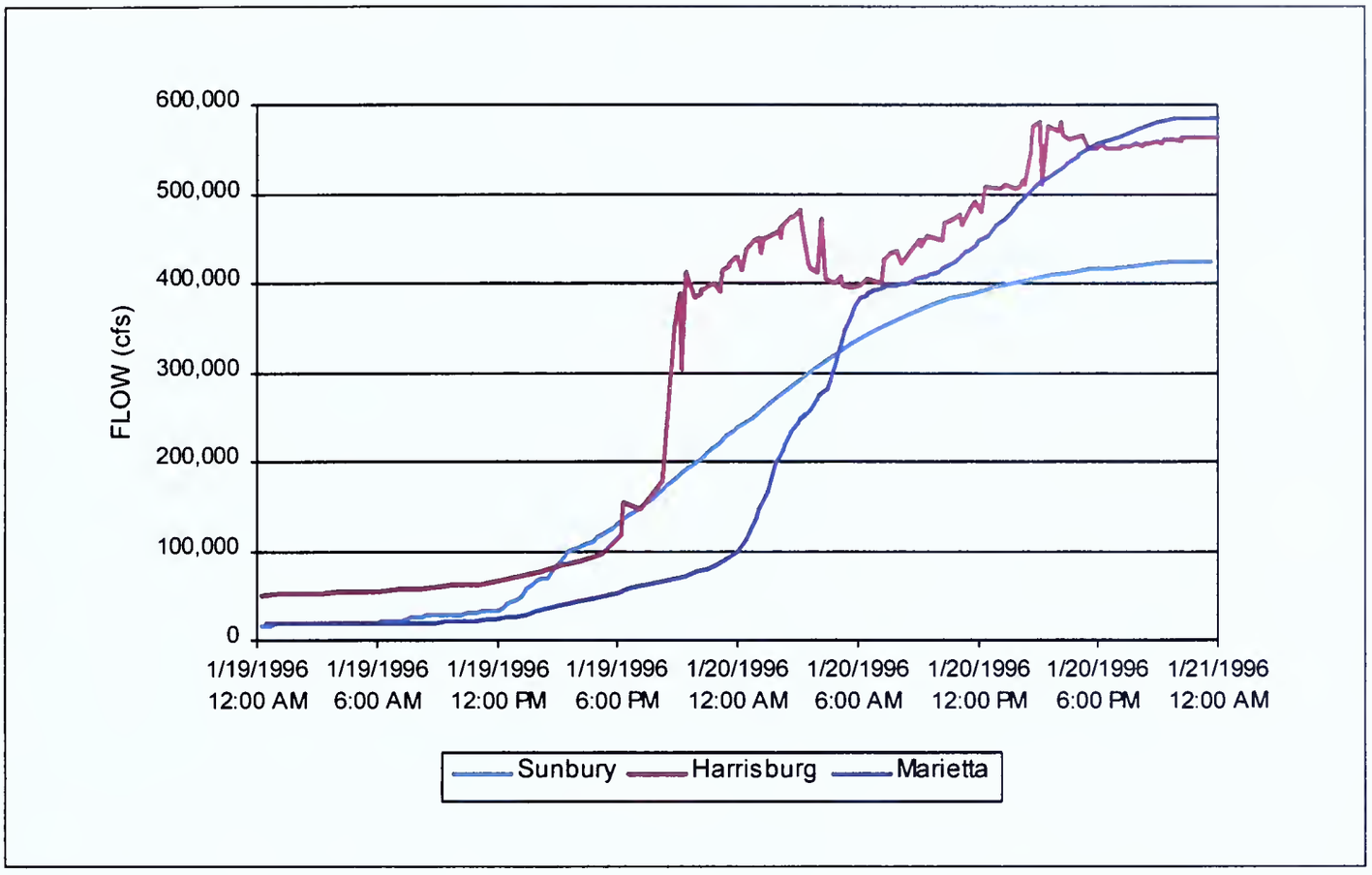



***Figure 1. Hydrographs at Sunbury, Harrisburg, and Marietta, Pa., During January 1996 Flood***

from about 12 feet to almost 20 feet between approximately 8:00 p.m. and 9:00 p.m. on January 19. Over the next several hours the stage continued to rise at a more gradual pace until the backwater reached its peak of 22.51 feet just after 3:00 a.m. on January 20. At the greatest differential, approximately 27,800 acre-feet of water were backed up. When the jam broke around 3:00 a.m., 19,000 acre-feet were released over the next 4 hours. After a brief surge, the river returned to its natural flow, but continued to rise to an eventual peak stage of 24.65 feet and peak flow of 568,000 cfs around 2:00 a.m. on Sunday, January 21.

The flow at Marietta, located about 25 miles downstream from Harrisburg, shows some of the effects of the jam at Harrisburg, especially from midnight to 9:00 a.m. on January 20. However, the hydrograph, overall, is relatively representative of the natural river flow and is probably a good estimate of the actual flow through the ice jam at Harrisburg (Figure 1). The flow peaked at about 600,000 cfs around 3:00 Sunday morning. The peak river stage overtopped the gage, so the peak flow had to be estimated.

Another much larger ice jam formed in the pool behind Safe Harbor Dam about 2.5 miles upstream of the dam during the early morning of Saturday, January 20. When compared to the Marietta hydrograph (Figure 2), it is clear Safe Harbor discharges were similar to the flows past Marietta until approximately 6:00 a.m. Saturday when ice from Harrisburg arrived. It is about this time the ice jam began to form 2.5 miles upstream of Safe Harbor. Some of the river water continued to flow towards Safe Harbor, but a portion of it began to back up behind the jam, as can be seen in the dip in the hydrograph for Safe Harbor. The operators at Safe Harbor first noticed the jam around 10:00 Saturday morning and notified Conowingo shortly thereafter. By this time, the water level had risen about 7 feet.

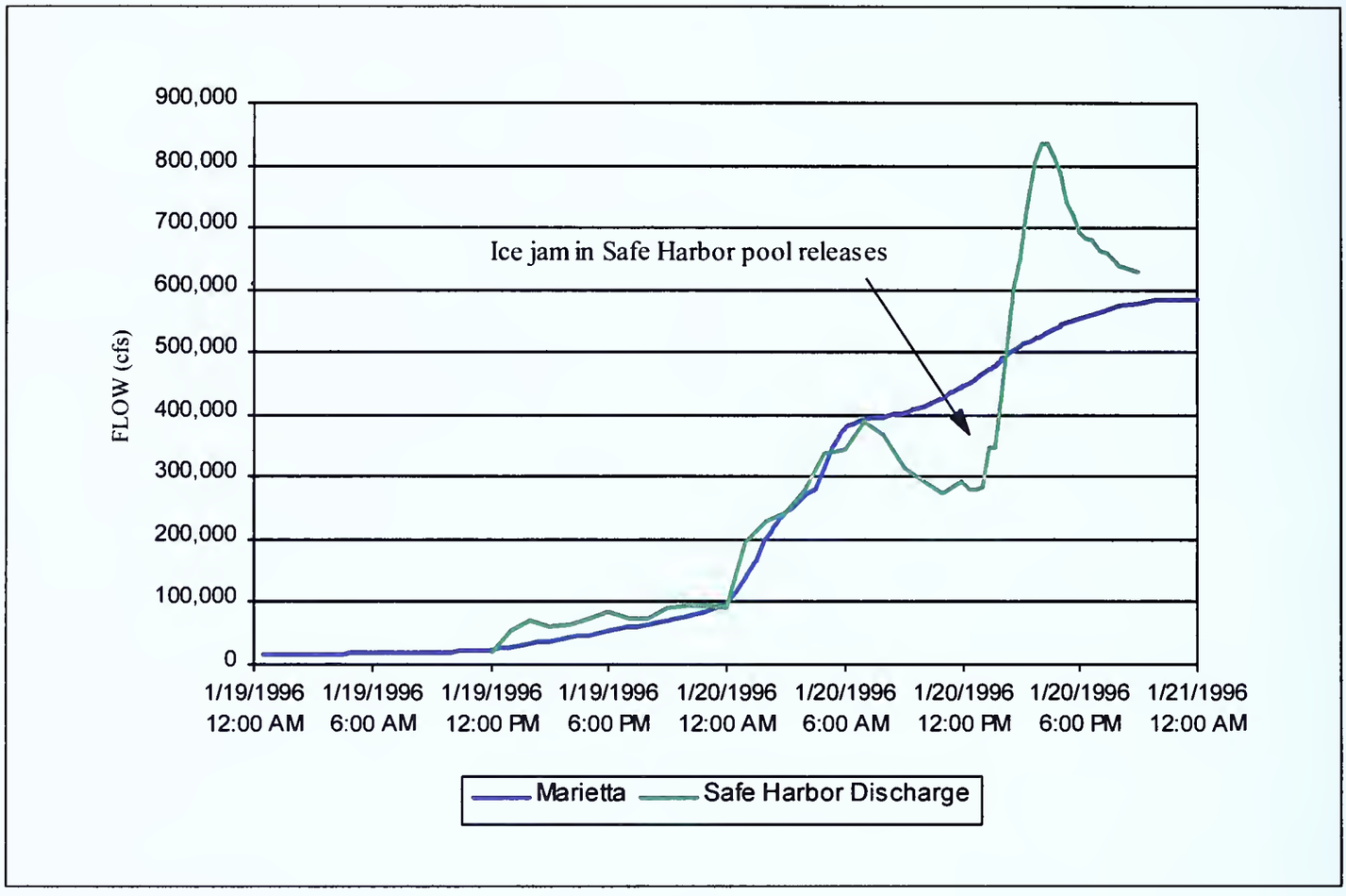



***Figure 2. Hydrographs at Marietta and Below Safe Harbor Dam***

Between 10:00 a.m. and Noon, the water levels behind Safe Harbor surged numerous times, causing problems in controlling forebay elevations (Figure 3). Plant operators attempted to keep the ice jam floating to minimize backwater by allowing more water passage. However, the backwater behind the jam eventually exceeded 8 feet. From past experience with ice jams, the operators at Safe Harbor know they cannot control the outcome when the backwater has reached this level. To prepare for a possible flood surge from the release of the jam, the forebay elevation was lowered 2 feet below normal to 225 feet. The ice jam released suddenly just after 1:00 p.m. Saturday, sending a wall of water downstream.

Normally when a jam breaks, a nearby upstream gage will reflect the release of the backwater by showing a reduction in stage. However, because the jam broke while the river was still rising, the river stage at Lock 2 (5 miles upstream of Safe Harbor Dam) did not drop, and the operators at Safe Harbor had no reason to believe the jam had broken. Nevertheless, the surge moved quickly towards the dam, and caused the elevation of the pond to rise 8.5 feet in just 10 minutes. The magnitude of the surge and the force of the large chunks of ice on the river were enough to topple a major portion of the skimmer wall structure at the dam. The operators at Safe Harbor began opening gates to lower the pool as quickly as possible to allow the surge to pass and to prevent further damage. However, because 15 minutes are required to open one gate, the flood waters continued to back up behind the dam. The pond eventually reached a stage of 234.5 feet, which is 7.5 feet above the normal operating elevation, and 9.5 feet above the pre-release elevation of 225 feet. The operators

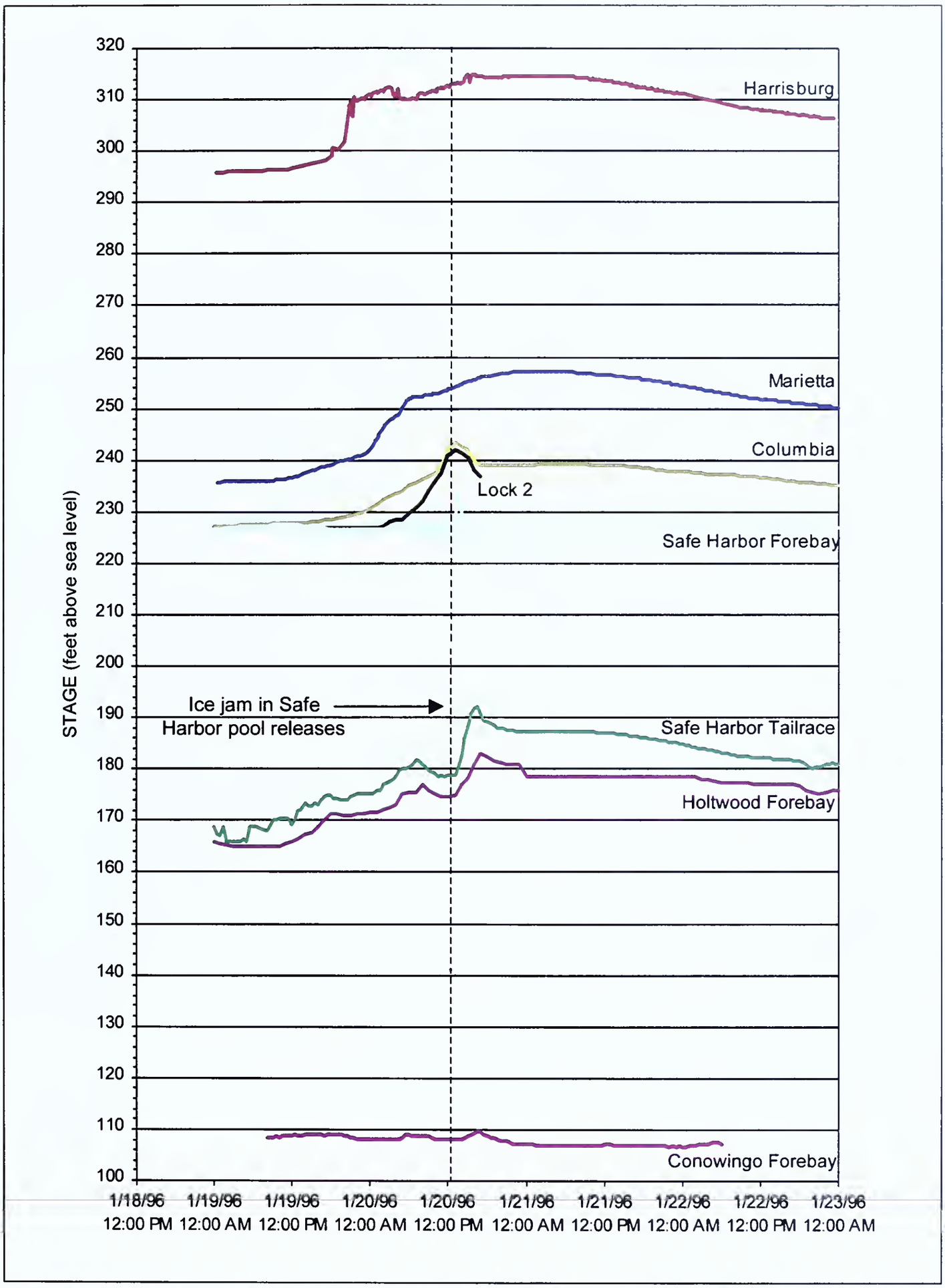



***Figure 3. Chronological Plot of Water Levels, January 19 Through January 22, 1996***

continued to open gates, eventually gaining control of the forebay elevation and allowing the surge to pass.

At the time of the release, approximately 70,900 acre-feet of water were stored behind the jam. The height of the backwater was 12.6 feet, and it was flooding some upstream areas. This ice jam event was unusual in that the backwater was released in just 2.5 to 3 hours, rather than over a period of several days. The resulting flood surge was close to 326,000 cfs. The natural flow of the river at the time of the release was around 500,000 cfs and still rising. The hydrograph in Figure 2 demonstrates the total discharge through Safe Harbor of 826,000 cfs.

The peak flow through Safe Harbor Dam was estimated to be lower than 826,000 cfs during the flood event. Ice accumulation caused an elevation differential across the east and west sides of the river at Safe Harbor, which caused the operators to underestimate flows for the remainder of the event. The temporary retention of the surge at Safe Harbor while the gates were being opened delayed and attenuated the surge to Conowingo somewhat, but it was still considerably higher than the natural river flow, which had now reached 520,000 cfs. Figure 3 demonstrates the retention of water between Safe Harbor and Lock 2, as well as the passing of the flood surge through Safe Harbor Dam and its progress towards Holtwood and Conowingo.

The surge moved rapidly towards Conowingo after flowing through Safe Harbor (Figure 4). Upon reports from Safe Harbor about the impending surge, the operators at Conowingo began to open gates to maintain the pool behind the dam at 108 feet. Because of the possibility of ice passing under the dam's skimmer wall and getting on top of or into the crest gates, which can prevent or interfere with their operation, it was decided not to lower the pool below an elevation of 108 feet.

The forebay elevation behind the Conowingo Dam rose very quickly as the operators attempted to open enough gates to control the surge. The elevation in the Conowingo pool reached a maximum of 109.8 feet at the dam. As a result, the elevation reached 111.8 feet at Peach Bottom Atomic Power Station, which is located in the Conowingo pool. The combination of the high stage with the high flows on the river necessitated a precautionary load reduction of 50 percent at Peach Bottom.

The Conowingo Dam had a maximum of 42 gates open to pass the surcharge, and the maximum discharge was measured at 909,000 cfs. Without the effect of ice, the natural peak of the flood would have been about 600,000 cfs, and would have occurred several hours later. Although the proper authorities were notified in the Town of Port Deposit, the unprecedented suddenness and quickness of the flood surge caught the residents by surprise. Over 100 homes were flooded, and several residents had to be rescued from the second floor of their homes.

The flood of January 1996 was very unusual in several ways. Ice jams do occur on the river from time to time, and can cause minor flooding when they release a surge of water. Likewise, the melting of snow is a common spring event, and may cause flooding when snow packs are large and temperatures rise to $50^{o}$F or more. However, the rapid succession of the jam release surge and the natural peak flow from the rapid snowmelt and rainfall is unusual. Adding to the severity of the flood, undoubtedly, was the quickness with which the river rose and the fact ice jams formed, causing surges on top of already high flows. This combination in January 1996 caused a natural flow of 500,000 cfs on the lower river to exceed 900,000 cfs.

Historically, in about 100 years of record, no other flood event witnessed the simultaneous breaking of a major ice jam with a very high flow event, e.g., 500,000 cfs. Conditions were similar in the 1936 St. Patrick's Day flood, but all of the ice jams broke about two days before the river flood crest arrived. In contrast, the 1996 flood occurred so suddenly that the ice jams were breaking as the high flows were surging through.

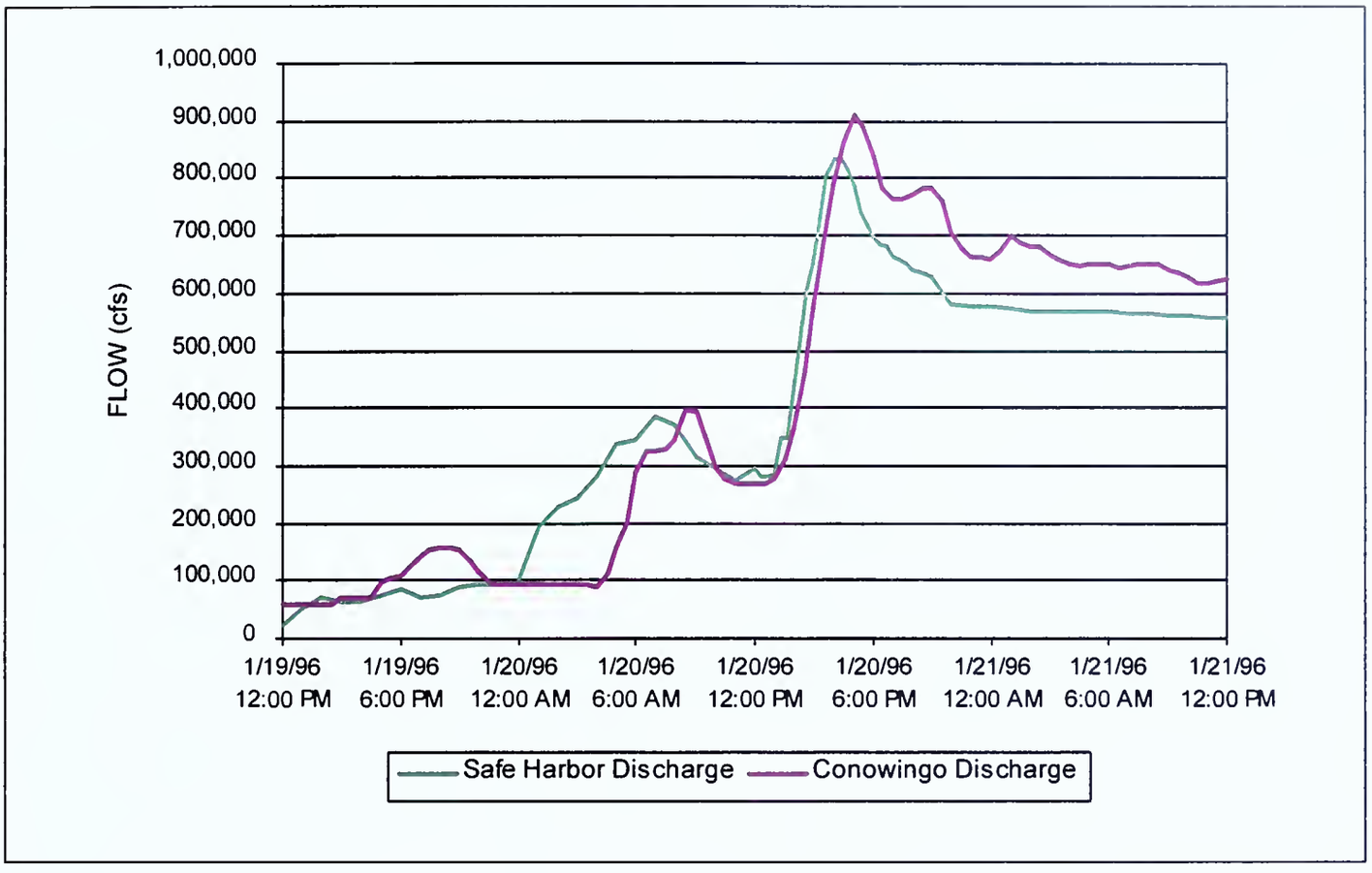



***Figure 4. Hydrographs of Discharge Through Safe Harbor and Conowingo Dams***

The Town of Port Deposit begins to experience extensive flooding when flows exceed 600,000 cfs. Therefore, for anticipated flows less than that, there is no reason for utility operations to be modified for the Town of Port Deposit.However, if there is an ice jam that has the potential to increase the peak flow above the 600,000 cfs threshold, then the utilities should consider taking measures to attempt to attenuate the flood waters, such as evacuating storage to absorb the impact of the surge.

## IDENTIFICATION OF PROBLEMS

Realizing the hydroelectric dams on the lower Susquehanna have virtually no capacity for flood control, the committee focused its efforts on improving other aspects of flood management. Extensive reviews of the event highlighted several areas of concern. It became apparent the January 1996 flood caught most parties by surprise and caught many unprepared, especially the Town of Port Deposit. The committee identified the lack of consistent, timely, and accurate information on the impending flood surge as a key problem area. Therefore, the committee concentrated its efforts on improving flood forecasting, ice monitoring, and communication and evacuation plans.

## RECOMMENDATIONS

### National Weather Service Categorical Flood Forecast System

The NWS developed a categorical river flood forecasting system for the Town of Port Deposit. The system forecasts the possibility of flooding and assigns a category ranging from nuisance

flooding to severe flooding. The forecasts are related to the number of gates open at Conowingo Dam and the stage at Harrisburg. However, the NWS will broadcast only the category of flood predicted, not the number of gates open at Conowingo. Statements and warnings issued by the NWS will be available over television and radio channels. The system will be implemented upon approval from officials of Cecil County, Maryland. See Appendix A for the categorical flood ranges.

## Ice Monitoring Plan

The committee agreed the most useful approach to predicting ice jam formation, breakup, and the resulting river flow effects for the Susquehanna River is improved observation and monitoring of ice conditions. The State College, Pa., office of the NWS is in the process of organizing a monitoring network at 20 to 30 areas in central Pennsylvania that have experienced ice problems in the past. The plan entails the enlistment of volunteer ice observers to monitor the ice and issue weekly ice statements to the NWS during static conditions. During periods of ice movement, more frequent statements will be issued, and downstream notification will begin.

The NWS has located a core group of volunteer observers. Additionally, the Army Corps of Engineers' Cold Regions Research and Engineering Laboratory has been contracted to conduct a training session for the observers. The Eastern region of the NWS has available some resources to fund the training session.

Safe Harbor will continue to operate their own ice monitoring system, thereby acting as NWS observers for the development and movement of ice in the area from Safe Harbor to York Haven. Weekly bulletins will be distributed to any concerned agencies, specifically the downstream power generation facilities and the NWS. Monitoring and issuing of bulletins will be done more frequently when conditions warrant. Additionally, the Safe Harbor operators will estimate the volume of backwater behind any ice jams should they be present. See Appendix B for the National Weather Service's and Safe Harbor's ice monitoring sheets.

## Utility/Agency River Monitoring and Communications Plan

The unpredictability of the behavior of ice and ice jams makes it difficult to mandate responses to rising water levels. The variability in conditions requires that the facilities have flexibility within their operating procedures. Also, the dams are designed for electric generation, not flood control, and have virtually no capacity for flood storage.

Therefore, improving communications between the facilities during alert situations offers the best hope of improving future management of flood waters. The utilities decided to cooperatively look into establishing radio communications between the facilities for use during emergencies. Although installing new equipment proved to be cost-prohibitive, existing radio equipment can be adapted to establish a radio network dedicated to communication between the utilities in the event of unusual conditions. Formal communication protocols for communication during ice jam emergencies have been outlined in the Utility/Agency River Monitoring and Communications Plan. Further, the additional communications and ice bulletins will enhance the ability of the NWS to make flood forecasts. Appendix C contains an outline of the adopted Communications Plan.

## Conowingo's Revised Flood Stage Maps for the Town of Port Deposit

SECO-Conowingo adapted SRBC flood inundation maps and the May 1996 revision to the Town of Port Deposit Notification and Evacuation Procedure to prepare an inundation map indicating the categorical flood forecasts of the NWS. A meeting was held on August 27 with representatives of the Town of Port Deposit, SECO, NWS, SRBC, and Cecil County to finalize levels of flooding for the map. The map

will be posted in the Town of Port Deposit by the Water Witch Fire Company, Incorporated. The inundation lines will correspond to the flood warnings made by the NWS and will delineate minor, moderate and severe flooding.

## CONCLUSIONS

An important lesson from the review of the January 1996 flood was the acknowledgment of the variety of factors causing the flooding and the various available options for future mitigation. Improved monitoring of ice conditions on the river is the first step in improved flood forecast and warning in the lower Susquehanna River. The ice monitoring network proposed by the NWS will provide information on the presence, location, and movement of ice on the river, and alert downstream facilities to the potential for ice jam problems. The ice season bulletin distributed by the Safe Harbor Water Power Corporation also will be invaluable in collecting and relaying pertinent ice information to the NWS and the other power facilities. Of special interest is Safe Harbor's estimate of the volume of backwater trapped behind any ice jams upstream of their dam. In the January 1996 flood, the release of backwater from an ice jam break nearly instantly increased the flow on the river from 500,000 cfs to 826,000 cfs.

The communication of ice presence or ice jam formation information is the next critical step in improving ice management. The most accurate predictions and estimates can be made only with the most up-to-date information. Minor communication breakdowns can cause delays in response times and forecast updates. The establishment of self-supporting radio communication links among the dams will eliminate delays caused by power or telephone line outages and system overloads. Improved communication among the facilities should help provide extra lead-time for evacuation of the Town of Port Deposit, as well as help avert problems such as a Peach Bottom load reduction.

With improved communication among the utilities and access to NWS forecasts, the dam operators will be able to better respond to the river conditions. The wide range of factors and types of ice will determine how the operators react. Options include lowering or raising pools in an attempt to break up ice in the very early stages, raising the pools to prevent ice damage, or lowering the pools to provide some attenuation of the flood. If ice jams, spillway flows or any other observations indicate that river flows are likely to exceed 600,000 cfs at the Conowingo Dam, notifications should be made to the appropriate agencies and individuals to prepare for flooding at the Town of Port Deposit.

The establishment of the ice monitoring network, categorical flood forecasts, and enhanced radio and telephone communications should help the utilities and involved agencies to better react and manage future flooding due to ice jam releases. In addition, the experience gained from the January 1996 flood and the extensive review performed afterwards should allow for better coordination and exchange of information among all involved parties as they work towards their common goal.

The commissioners of SRBC are preparing an endorsement of the accomplishments of the ICEJAMS Committee. The recommendations made in this report will be implemented before the 1996-97 winter season and subject to a performance test. By October 1 of every year, the committee will review the performance of the program and make refinements or improvements, if necessary.

# Appendix A

# National Weather Service Categorical Flood Forecast System

## CATEGORICAL FLOOD LEVELS FOR PORT DEPOSIT, MARYLAND

These forecasts will be disseminated through the National Weather Wire Service, The Family of Services (this goes to the media and private weather groups), via FAX to Cecil County EMA and placed on the Philadelphia NOAA Weather Radio (KIH-28 162.475 MHz).

The forecasts will be based on the Mid-Atlantic River Forecasting Center's stage forecasts for the Susquehanna River at Harrisburg and Marietta, Pa., and the stage relation at Conowingo.

| Harrisburg Forecast | Marietta Forecast | Degree of Flooding | Gates Open |
|---|---|---|---|
| up to 11 ft | up to 45 ft | none | 1 - 10 |
| 11 to 13.5 ft | 45 to 48 ft | inconvenience flooding; Md. Route 222 closed | 11 - 15 |
| 13.5 to 23 ft | 48 to 55 ft | minor flooding; nearing problems | 16 - 30 |
| 23 to 25 ft | 55 to 57 ft | moderate flooding | 31 - 35 |
| >25 ft | >57 ft | severe flooding | 36 - 50 |

Estimated travel time: Harrisburg to Marietta 6 to 7 hours
Marietta to Conowingo 2 to 3 hours

# Appendix B

## Ice Monitoring Worksheets: National Weather Service and Safe Harbor Water Power Corporation

# SUSQUEHANNA RIVER BASIN ICE REPORT

Please fill out this form each Friday and mail to the NWS.
Please call in reports of ice breakup or jamming: 1-800-826-5860.
**PLEASE MAKE ALL OBSERVATIONS A SAFE DISTANCE AWAY FROM THE RIVER**
**DO NOT VENTURE OUT ONTO THE ICE**

Date/Time: _____ Location: _____

1. FREEZEUP

   Border ice: growth from shore _____ ft

   Moving ice: types _____ frazil slush _____ frazil pans _____ pieces of sheet ice

2. INTACT ICE COVER

   Date of complete ice cover _____ mm/dd/yy

   Location of downstream end of ice cover _____

   Location of upstream end of ice cover _____

   Degree of Decay (circle one) No decay Snow-covered Melting snow Candled ice

3. BREAKUP **PLEASE PHONE IN OBSERVATION**

   Time ice started to move: _____ a.m./p.m. _____ mm/dd/yy

   Time water is clear of ice: _____ a.m./p.m. _____ mm/dd/yy

   Estimated height of shear walls remaining along bank _____ ft

4. ICE JAMS **PLEASE PHONE IN OBSERVATION**

   Type (check one) _____ Freezeup _____ Breakup

   Jam initiation point (check as many as applicable)
   _____ solid ice sheet _____ constriction in river channel
   _____ island _____ bridge
   _____ bend _____ other _____

   Location of ice jam toe (downstream end) _____

   Estimate of Jam length: _____ miles

   Backwater behind jam: _____ yes _____ no

   If yes, river level is _____ rising _____ steady _____ falling

   River out of banks _____ yes _____ no

   Estimated height of shear walls after jam release _____ ft

# SAFE HARBOR WATER POWER CORPORATION

## ICE SEASON BULLETIN NO. _____ DATE _____

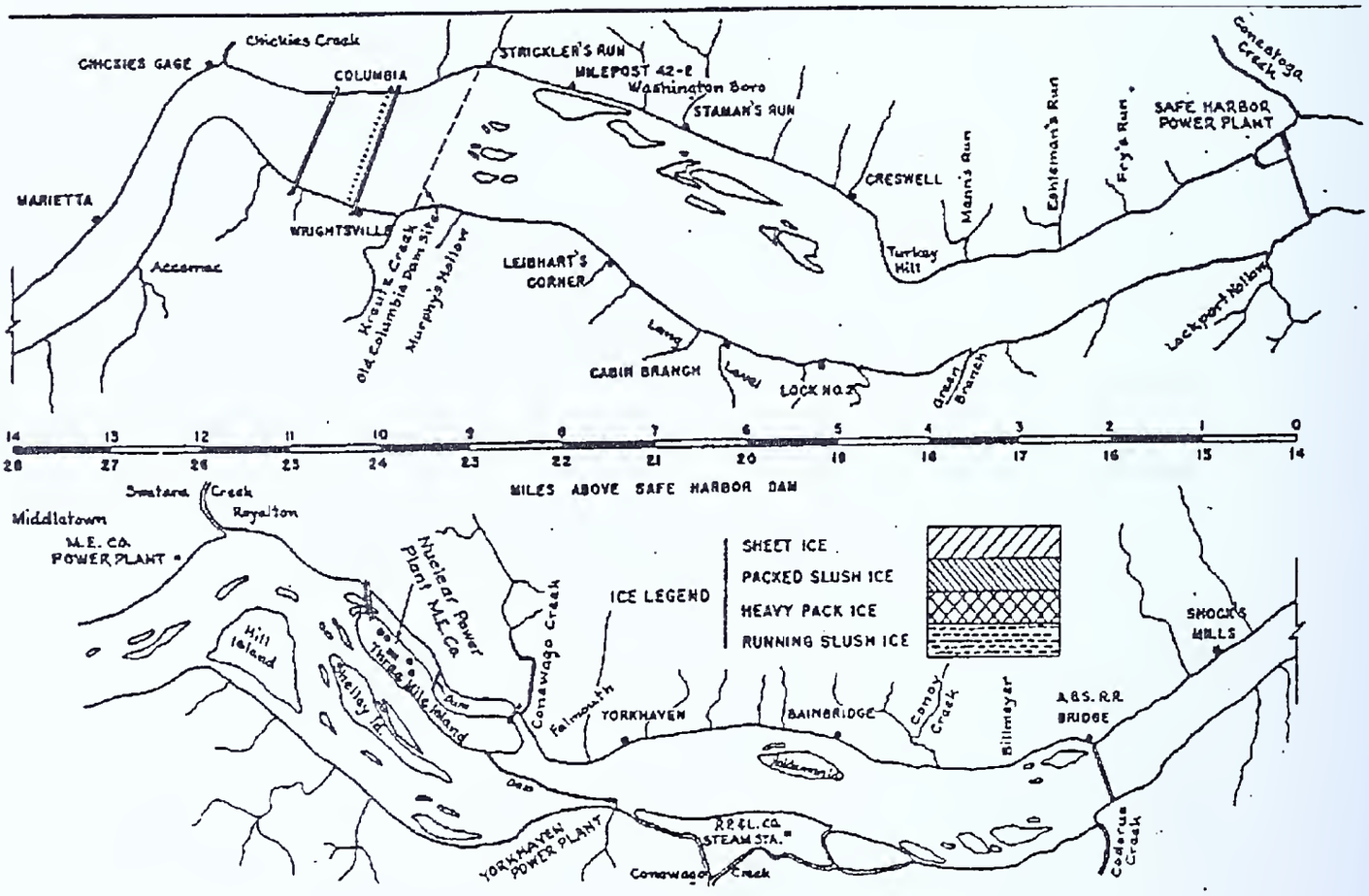
| TEMPERATURES AT SAFE HARBOR | AIR | | WATER | |
|---|---|---|---|---|
| AT 9:00 A.M. | ° F. | ° C. | ° F. | ° C. |
| LOWEST LAST 24 HOURS | ° F. | ° C. | ° F. | ° C. |
| HIGHEST LAST 24 HOURS | ° F. | ° C. | ° F. | ° C. |

PRECIPITATION LAST 24 HOURS - RAIN IN. - SNOW IN. - WATER EQUIVALENT IN.

GENERAL CONDITIONS -

| RIVER FLOW (CFS) 9:00 AM - | | | |
|---|---|---|---|
| RIVER STAGES 9:00 AM | | | |
| GAGING STATIONS | ELEVATION (FT) | BACKWATER (FT) | BACKWATER YESTERDAY (FT |
| FOREBAY | | | |
| LOCK No. 2 | | | |
| COLUMBIA | | | |
| CHICKIES | | | |
| APPROX. FLOW EQUIVALENT CONTAINED IN BACKWATER (CFS) - | | | |
| 9:00 AM RIVER FLOW (CFS) + BACKWATER (CFS) - | | | |
| ALERT LEVEL | (River/Ice conditions - Level I. [minor] to Level V. [major release of ice and water]) | | |

## ICE CONDITIONS



# Appendix C

# Utility/Agency River Monitoring and Communication Plan

# ICE JAMS
## UTILITY/AGENCY RIVER MONITORING AND COMMUNICATIONS PLAN

Notification Levels For Changing River Conditions:

**LEVEL I: "ICE COVER"** (Observation on Safe Harbor Pond)

A. Safe Harbor initiates the Ice Bulletin
B. Ice Bulletin to be published weekly by Safe Harbor
C. Safe Harbor faxes Ice Bulletin to the bulletin entity mailing list

The Ice Bulletin mailing list includes the following entities:

Orin L. O'Donel
Manager of Engineering
Safe Harbor Water Power Corp.
1 Power House Road
Conestoga, PA 17516
Phone: (717) 872-0274
Fax: (717) 872-0282

Rich Olin
Chief Water Control
U.S. Corp. of Engineers
P.O. Box 1715
Baltimore, MD 21203
Phone: (410) 962-4893
Fax: (410) 962-4972

Tom Baumgardner
David Ondrejik
Hydrologist-in-Charge
Middle Atlantic Forecasting Serv.
227 W. Beaver Ave., Suite 402
State College, PA 16801
Phone: Ondrejik: (814) 234-9412
(814) 237-1152
Baumgardner: (814) 234-9780
Fax: (814) 234-9703

Mark Arbogast
Land Management Supt.
Pennsylvania Power & Light Co.
9 New Village Road
Holtwood, PA 17532
Phone: (717) 284-2278
Fax: (717) 284-6288

Shift Supervisors -
Holtwood Operations
Pennsylvania Power & Light Co.
482 Old Holtwood Road
Holtwood, PA 17532
Phone: (717) 284-6212/4101
Fax: (717) 284-6234

T. C. Tierney
Division Engineer
Conrail Corporation
1000 Howard Blvd.
Mt. Laurel, NJ 08054
Phone: (609) 231-2021
Fax: (609) 231-2028

Plant Control Room Operator -
Holtwood Hydro
Pennsylvania Power & Light Co.
482 Old Holtwood Road
Holtwood, PA 17532
Phone: (717) 284-6217/6260
Fax: (717) 284-6296

Conowingo Control Room Operator
Conowingo Hydro Station
Susquehanna Electric Company
2569 Shures Landing Road
Darlington, MD 21034
Phone: (410) 457-2422/2423
Fax: (410) 457-2511

Darryl Johnson
Jr. Analyst
Conowingo Hydro Station
Susquehanna Electric Company
2569 Shures Landing Road
Darlington, MD 21034
Phone: (410) 457-2515
Fax: (410) 457-2485

Control Room Shift Supervisor
Peach Bottom Atomic Power Station
(PBAPS)
PECO Energy Company
RR1, Box 208
Delta, PA 17314-9739
Phone: (717) 456-4687/4688
Fax: (717) 456-4793

Douglas E. Weaver
Manager, York Haven Generating Station
501 Parkway Blvd.
York, PA 17404-2699
Phone: (717) 848-7278
Fax: (717) 848-7163

Walt N. Nickelsberg
Service Hydrologist
National Weather Service
732 Woodlane Road
Mount Holly, NJ 08060
Phone: (609) 761-6605 (ext. 232) or
(800) 523-4129
Fax: (609) 261-6614

John E. McSparran
Chief Engineer
Susquehanna River Basin Comm.
1721 North Front Street
Harrisburg, PA 17102-2391
Phone: (717) 238-0423
Fax: (717) 238-2436

## LEVEL II: "SIGNIFICANT ICE BUILD UP"

A. Based on Safe Harbor "Degree Day" calculation
B. Based on river observations above York Haven Power Plant by NWS and NWS observation network. (Network of observers to be established.)
C. Based on Safe Harbor observations of significant (4" - 6") buildup of ice cover on Safe Harbor pond and/or on the river area up to York Haven Power Plant and the beginning of volume of backwater accumulation above Safe Harbor. Safe Harbor will document the ice level condition on the weekly Ice Bulletin.
D. Notifications

Safe Harbor notifies National Weather Service (NWS) offices listed below of the change to Level II status "Significant Ice Build Up".

1. Dave Ondrejik
   State College, PA
   1-800-697-0010 or
   1-814-234-9412 or
   1-814-237-1152 (Operations area – 24 hours)

2. Walt Nickelsberg
   Mount Holly, NJ
   1-800-523-4129 or
   1-609-261-6605 (ext. 232)

E. Safe Harbor continues to fax weekly Ice Bulletins to entity mailing list as referenced in Level I (C). Level II ice conditions will be noted on the Ice Bulletin.

## LEVEL III: "ICE JAM WATCH" (Initiated/declared by Safe Harbor)

A. "Ice Jam Watch" declared by Safe Harbor Water Power Corporation (SHWPC) after consultation with the NWS and SHWPC determines the possibility of greater than 80,000 cfs river flow plus significant ice formation. Possible factors to be considered in forecast:

1. Rainfall or significant temperature increase and/or
2. Snow cover and/or
3. Water equivalent snow pack and/or
4. Safe Harbor increase of back water volume

B. Notifications:

1. After Safe Harbor declares "Ice Jam Watch", Safe Harbor notifies all agencies and utilities by issuing an Ice Bulletin indicating a Level III condition via fax list.
2. Safe Harbor notifies NWS and SRBC offices of the Level III "Ice Jam Watch":

   a. Dave Ondrejik, NWS
      State College, PA
      1-800-697-0010 or
      1-814-234-9412 or
      1-814-237-1152
   b. Walt Nickelsberg, NWS
      Mount Holly, NJ
      1-800-523-4129 or
      1-609-261-6605 (ext. 232)
   c. John McSparran, SRBC
      Harrisburg, PA
      1-717-238-0423
      1-717-367-2282 (home)

3. • Safe Harbor Hydro Coordinator initiates direct communication among power plants and notifies utility personnel as listed below of the Level III "Ice Jam Watch" declaration.

   • Safe Harbor will advise and request <u>all utility radios be turned to "on" position and tested but continuous monitoring is not required at this level</u>.

   • The person contacted at each power plant will advise appropriate station personnel of the Level III "Ice Jam Watch" declaration.

   • Utility personnel to be contacted are listed under Item Number 4 below with primary and alternate personnel names and telephone numbers.

- Safe Harbor will document all notifications with dates, times, names, etc.

4. Safe Harbor initiates conference call between power plants at Supervisor of Operations level or equivalent or designee. The responsible person at each station shall contact and supply to the Safe Harbor Hydro Coordinator at (717) 284-0211 the name, telephone number and time of availability of the station conference call person.

   Points to be discussed include:

   - Frequency of ice bulletins
   - Operations plans at each plant
   - Forecast information (from Safe Harbor or NWS)
   - Range of worst-case scenarios given present conditions
   - Confirmation of radio operations
   - Upstream conditions

   a. Holtwood

      (1) Hydro Plant Control Room Operator (717) 284-6217/6260
      (2) Shift Supervisor (717) 284-6212

   b. York Haven

      (1) Switchboard Operator (717) 848-7278
      (2) Station Manager (717) 848-7278, Beeper # (717) 849-9609
      (3) Titus Station Power Plant, Shift Supervisor (610) 378-8401

   c. Conowingo Hydro Station

      (1) Control Room Operator (410) 457-2422/2423 or (410) 457-2400
      (2) Glenn M. Kelly, Operations Supervisor (410) 457-2416
      (3) William L. Peirson, Environmental Specialist (410) 457-2407

5. Conowingo Control Room Operator contacts Peach Bottom Shift Manager by calling the telephone numbers listed below and advises that Level III "Ice Jam Watch" has been initiated.

   a. Peach Bottom

      Control Room Shift Supervisor 807:4687, 4688, 4221 (internal) or (717) 456-4687
      Fax # 807:4793 (internal) or (717) 456-4793

   **OR**

      Contact Control Room Shift Manager through System Operations Load Dispatcher 801:5142 (internal) or (215) 841-5142 or L.D. radio

## LEVEL IV: "ICE MOVEMENT WARNING" (Initiated/declared by NWS or Safe Harbor)

A. Triggers:

1. River gauge and visual river observations by Safe Harbor
   or
2. Backwater level increasing at Safe Harbor
3. NWS Network notification as a result of river gauge and/or visual river observations
4. Ice jam breakup as observed and reported to Safe Harbor by any utility, NWS or SRBC

B. Notifications:

1. Safe Harbor initiates continuous radio communication between utilities, as listed under Level III B.3 and requests all radios on and being monitored.
2. Conowingo Control Room Operator contacts Peach Bottom, as listed under Level III B.5 and advises that Level IV "Ice Movement Warning" has been declared.
3. Safe Harbor and Conowingo contact the NWS and SRBC offices, as listed under Level III B.2

   a. If/when ice movement noted
   b. Changes in river flow and/or plant discharge
   c. Changes in ice level and/or significant pond elevation changes
   d. Quantity and type of ice observed
   e. Observations and river information/conditions obtained from Holtwood and York Haven

4. NWS communicates "Ice Movement Warning" to:

   a. Public via NWS communication networks
   b. Safe Harbor Control Room/Hydro Coordinator (717) 872-0211

      (1) Safe Harbor communicates to utilities via radio network

5. Conowingo Control Room Operator contacts Peach Bottom as listed under Level III B.5 and communicates ice movement information.

## LEVEL V: "SURGE FLOW DUE TO ICE JAM RELEASE" (As observed or reported by any utility, NWS or SRBC)

A. Trigger:

1. Gauge and visual river and ice observation by any utility, NWS, or SRBC

B. Notification by utilities:

1. Continuous utility radio communication to other power plants as initiated in Level IV B.1

2. Conowingo notifies:

   a. NWS office at Mount Holly, New Jersey
      Walt Nickelsberg
      Mount Holly, NJ
      1-800-523-4129 or
      1-609-261-6605 (ext. 232)
   b. Peach Bottom, as listed under Level III B.5

      .Control Room Shift Supervisor 807:4687, 4688, 4221 (internal) or (717) 456-4687
      Fax # 807:4793 (internal) or (717) 456-4793

**OR**

      Contact Control Room Shift Manager through System Operations Load Dispatcher 801:5142 (internal) or (215) 841-5142 or L.D. radio

   and provides information on:

   (1) Actual current river flow and plant discharge
   (2) Projected river flow and plant discharge
   (3) Any other relevant river, ice, discharge, pond elevation, etc., conditions and observations

3. Safe Harbor remains in communication with the NWS (see II D) and provides:

   Dave Ondrejik
   State College, PA
   1-800-697-0010 or
   1-814-234-9412 or
   1-814-237-1152

   Walt Nickelsberg
   Mount Holly, NJ
   1-800-523-4129 or
   1-609-261-6605 (ext. 232)

   a. Actual river flow, plant discharge and pond elevation
   b. Projected potential river flow and changes in plant discharges and forebay elevations
   c. Type and volume of ice being observed in pond and being discharged downriver

C. NWS or SRBC shall contact Safe Harbor with any significant change in river conditions observed at Harrisburg and downriver area below Harrisburg.

   1. NWS contacts Safe Harbor Control Room/Hydro Coordinator at (717) 872-0211

D. Safe Harbor Control Room/Hydro Coordinator shall communicate all pertinent river flow information received from any and all sources to other power plants via radio network.

## LEVEL OF ALERT REPORTING FREQUENCY

The level of alert for ice jams will be updated based on the severity of the level. For example, a Level I or II alert is updated weekly by Ice Bulletin.

For Level III and higher, an Ice Bulletin will be issued three times a week.

Level III status will be updated daily. Level IV and V updates will be through continuous radio communication or phone as appropriate and will be done at least once per 4 hours and as frequently as one hour, as conditions dictate.

## REDUCING ALERT LEVEL

Safe Harbor will communicate reductions of alert levels at the same frequency as noted in "Level of Alert Reporting Frequency".

## PROCEDURE FOR REVISING PLAN

1. SRBC shall coordinate annual revisions and modifications to operation plan, no later than October 1 of each year.

2. Any minor changes or problems shall be reported to SRBC for correction.